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# EFFECTS OF SULPHUR DIOXIDE AND HEAVY METALS ON VEGETATION IN THE SUDBURY AREA

(1974)



Ontario

Ministry  
of the  
Environment

Northeastern Region  
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Director

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Effects of Sulphur Dioxide and Heavy Metals  
on Vegetation in the Sudbury Area (1974)

By

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Northeast Region

June, 1975

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## I. Introduction:

Sulphur dioxide emissions from the Sudbury area smelters of the International Nickel Company and Falconbridge Nickel Mines have been monitored by various Departments and Ministries of the Ontario Government since 1953. The network initially consisted of 5 Thomas autometers situated at Burwash, Skead, Grassy Lake, Garson, and Bear Island. Since 1953 the network has been expanded into areas where vegetation was being injured by sulphur dioxide. During 1974, the network consisted of 12 Davis instruments. The locations of these 12 stations and the smelters are shown in figure 1 on page 13. When the network was first set up the recorders were operated only during the growing seasons. In 1973 all the recorder stations except Kukagami Lake and Grassy Lake were winterized and are now operated on a year round basis. In this report the data for the growing seasons only are reported. In addition to this network of instruments, the Ontario Ministry of the Environment operates two air pollution index stations on a year round basis, one in the City of Sudbury and one in the Town of Coniston.

A number of complaints of vegetation injury by air pollutants were received, investigated and reported on by Ministry personnel during 1974. In addition to complaint investigations, a general surveillance program was carried out to assess the incidence and extent of vegetation injury in the Sudbury area by air pollutants and other agents.

In 1970, the Phytotoxicology Section of the former Air Management Branch began sampling vegetation and soil in the Sudbury area at a number of locations for chemical analysis. The program has been continued during the growing seasons since 1970. The data pertaining to the chemical analysis of soil and vegetation samples are presented in this report.

## II. Sulphur Dioxide Levels - 1974 (May - October)

### (a) Daily Measurements:

In Table 1 on page 16, the number of hours of sulphur dioxide recorded at each of the 12 stations during the season are shown. A total of 7,244 hours of SO<sub>2</sub> were recorded during a total sampling time of 47,629 hours. (Table 2) This means that some level of SO<sub>2</sub> was being recorded approximately 15% of the sampling time. During a similar period in 1973, SO<sub>2</sub> was recorded during 24% of the sampling time. Valid data were collected on the average over 90% of the time during both seasons. In the following table, the number of days the recorders were operated, as well as the number of days some level of SO<sub>2</sub> was recorded, and the maximum one hour concentrations are listed.

<u>Station</u>	<u>Operative Days</u>	<u># of Days With SO<sub>2</sub></u>	<u>Max. 1 Hr. Conc. (ppm)</u>	<u>Date</u>
Garson	184	124	0.65	Oct. 3rd
Skead	183	124	1.06	May 12th
Kukagami Lake	92	61	0.84	Oct. 3rd
Grassy Lake	148	89	0.61	Oct. 3rd
Lake Penage	181	33	0.35	May 9th
Morgan	169	52	0.68	May 20th
Burwash	150	69	0.38	Oct. 3rd
Rayside	175	97	0.45	June 16th
St. Charles	170	84	0.22	Aug. 13th
Callum	184	110	0.90	Aug. 30th
Verner	151	46	0.17	Aug. 17th
Hanmer	181	113	1.06	Aug. 15th
TOTAL	1,968	1,002		

In the above table the number of days the monitors were operated and the number of days that some level of SO<sub>2</sub> was recorded are listed. The recorders were operated a total of 1,968 days and some level of SO<sub>2</sub> was recorded on 1,002 days. The maximum one hour reading was 1.06 ppm and this was recorded on May 12th at the Skead station and August 15th at the Hanmer station.

In the following table, the distribution of the SO<sub>2</sub> readings at the various area stations for 1974 are shown. Only two readings were above 1.00 ppm, while 50, (0.7%), were above 0.50 ppm, and 249, (3%), were above 0.25 ppm. A total of 5659 readings, (78%), were in the 0.01 - 0.04 ppm range and 7,025, (97%) were in the 0.01 - 0.25 ppm range.

DISTRIBUTION OF SO<sub>2</sub> READINGS - 1974

<u>Station</u>	<u>.01 - .04</u>	<u>.01 - .25</u>	<u>.25+</u>	<u>.50+</u>	<u>1.00+</u>
Garson	708	885	45	3	0
Skead	636	1014	126	31	1
Kukagami Lake	224	365	4	1	0
Grassy Lake	562	630	3	1	0
Lake Penage	110	167	5	2	0
Morgan	457	471	5	2	0
Burwash	336	429	6	0	0
Rayside	797	837	5	0	0
St. Charles	563	616	0	0	0
Callum	468	629	20	3	0
Verner	122	147	0	0	0
Hanmer	676	835	33	9	1
TOTAL	5,659	7,025	249	50	2

(b) Monthly Measurements:

In Table 1 of this report the SO<sub>2</sub> data collected at the 12 Sudbury monitors is summarized on a monthly basis from May to October.

There was a wide variation in the frequency and concentration of SO<sub>2</sub> from station to station and from month to month. Some level of SO<sub>2</sub> was recorded at each station every month. This ranged from a maximum of 245 hours at Hanmer in September to two hours at Kukagami Lake in October.

The 0.25 ppm level was exceeded every month of the season at the Skead and Garson stations. This level was exceeded every month but July at Hanmer, every month but October at Callum, at Kukagami Lake during May, September and October, and at Burwash during May, July, September and October. The 0.25 level was exceeded at the other stations during less than 3 of the six months.

The 0.50 ppm level was exceeded at Skead each month during the 1974 growing season. In addition, this level was exceeded in May at Garson, Morgan and Hanmer, at Callum and Hanmer in June, August and September and at Garson, Kukagami Lake, and Grassy Lake in October.

(c) Yearly Measurements:

Abatement programs at both International Nickel and Falconbridge Nickel Mines over the past several years have substantially reduced the amount of SO<sub>2</sub> being emitted to the atmosphere. Some of the major reasons for the reductions are the following:

- 1) The introduction of the 1250 foot stack at Copper Cliff on August 21st, 1972.
- 2) The closing down of the International Nickel smelter at Coniston and pyrrhotite plant at Falconbridge prior to the 1972 growing season.
- 3) Production cut back at both companies at critical times.
- 4) Limitations on the output of SO<sub>2</sub> at the Inco iron plant.

In Table 1 the average monthly SO<sub>2</sub> concentrations for SO<sub>2</sub> periods only and "total period" for the 1973 and 1974 seasons are compared to a mean calculated for each station, 1960 - 1971 excluding the strike years of 1966 and 1969.

The monthly averages for all months in 1973 and 1974 are substantially lower than the means for each station. The means for several months in 1974 were higher than the means for the same months in 1973.

During 1973 there were 8,774 one hour SO<sub>2</sub> readings recorded at 11 stations and during 1974 there were 7,244 readings recorded at 12 stations. Over the past few years there has not been a substantial reduction in the number of readings, however there has been a substantial reduction in the number of readings in the 0.25+ ppm, 0.50+ ppm and 1.00+ ppm categories.

III. Potentially Injurious Fumigations (P.I.F.):

Observations made in the Sudbury area over the past several years indicate that acute injury may occur to vegetation when the following levels of sulphur dioxide are reached or exceeded for the following time periods during daylight hours:

0.95 ppm for 1 hour  
or 0.55 ppm for 2 hours  
or 0.35 ppm for 4 hours  
or 0.25 ppm for 8 hours

For convenience, a factor of 100 has been assigned

to any of the above combinations and any fumigation which reaches or exceeds these levels is termed a P.I.F.

A fumigation with a calculated intensity of 100 does not always injure vegetation. Vegetation, in general, is more sensitive to SO<sub>2</sub> early in the growing season when the growth rate is the highest. There is also a variation in the sensitivity of various plant species to sulphur dioxide. White birch and trembling aspen are very sensitive to SO<sub>2</sub> injury, while white spruce and oak are very resistant.

A total of 17 P.I.F. were recorded at the 12 Sudbury area recording stations during May - October, 1974. Nine were recorded at Skead, three at Hanmer, two at Garson and one each at Kukagami Lake, Morgan and Callum. In Table 3, the dates and intensities of the 17 P.I.F. are listed. Three P.I.F. were recorded in May, June, September and October, five in August and none in July. If P.I.F. had occurred during the month of July, vegetation injury by SO<sub>2</sub> would probably have been more common in the Sudbury area.

In the table below, the number of P.I.F. recorded in the Sudbury area during the last ten years are listed. (see also Figure 3)

<u>Year</u>	<u>Number of</u> <u>Potentially Injurious</u> <u>Fumigations</u>	<u>Year</u>	<u>Number of</u> <u>Potentially Injurious</u> <u>Fumigations</u>
1974	17	1969 (strike year)	34
1973	7	1968	50
1972	27	1967	73
1971	61	1966 (strike year)	34
1970	64	1965	43

In 1974, there were 12 monitoring stations; in 1973, there were 11; and during the other years, there were 10.

A fumigation which occurred on October 3, 1974, was registered as a P.I.F. at Garson and Kukagami Lake, and had an intensity factor of 94 at Skead and 99 at Grassy Lake. On October 3rd, winds in the Sudbury area were of low velocity and mainly out of the southwest. Since these stations are to the northeast of Sudbury, it can be concluded that the levels of SO<sub>2</sub> at Garson were caused by Inco emissions and the levels at the other 3 stations were a combination of the emissions from Inco and Falconbridge.

#### IV. Complaints of Vegetation Injury by Air Pollutants:

A total of 46 complaints of possible vegetation injury were received, investigated and reported on by the Ministry of the Environment personnel during the 1974

growing season. In all but two cases, mutually acceptable settlements appear to have been reached between the complainants and the sources without appealing to the Board of Negotiation.

In 1971, the Ontario Environmental Protection Act, which provides for the mediation of damage claims by a Board of Negotiation was established. No claims were mediated by the Board in the Sudbury area during the 1971, 1972 or 1973 seasons. A negotiation hearing was held in Sudbury to settle the two outstanding complaints from 1974.

More complaints were received during 1973 than any season since 1970. In the table below, the number of complaints received during the past 5 seasons in the Sudbury area is shown as well as the number diagnosed as SO<sub>2</sub> injury.

<u>Year</u>	<u>Number of Complaints Received</u>	<u>Number Diagnosed as SO<sub>2</sub> Injury</u>
1974	46	20
1973	65	15
1972	27	15
1971	14	10
1970	16	9

Fewer complaints were received during 1974 than 1973, however there were more complaints diagnosed as SO<sub>2</sub> injury in 1974 than in any of the last five years.

Other types of vegetation injury observed on the complainants' properties included insect and fungal injury, physiological injury and abnormalities caused by poor cultural practices.

#### V. Vegetation Injury During 1974:

Personnel of the Ministry of the Environment conducted a detailed surveillance program in the Sudbury area during the 1974 growing season in order to document the incidence and extent of vegetation injury by SO<sub>2</sub>. Acute SO<sub>2</sub> injury was observed over a somewhat smaller area during 1974 than in 1973. This is probably due to the fact that a large number of the potentially injurious fumigations occurred either early or late in the growing season when vegetation tends to be resistant to SO<sub>2</sub> injury. There were no potentially injurious fumigations recorded at any of the 12 area monitors during the entire month of July.

No acute SO<sub>2</sub> injury was observed on any cultivated or indigenous species of vegetation in the Sudbury area during the months of May, September, and October.

Trace to light (6-15% of leaf area affected) SO<sub>2</sub> injury occurred on vegetables in gardens in the Hanmer area during the third week in June. Sulphur dioxide was recorded at the Hanmer station on June 14th, 15th, 17th, and 19th. These fumigations were probably a combination of the emissions from both smelters. Another fumigation sometime during the last week in June caused trace to light injury on vegetables in the Coniston area. The source of this fumigation is believed to be the Falconbridge smelter. Beans and peas seemed to be the most severely injured by these fumigations.

Fumigations of sulphur dioxide in early July caused trace injury on such agricultural crops as oats, barley and buckwheat in the Hanmer area. It is believed that the source of the fumigations which caused this injury was the Falconbridge smelter.

On July 25th, 1974, a fumigation of sulphur dioxide from the Falconbridge smelter caused the most severe injury to vegetation documented during 1974. Indigenous vegetation such as white birch and trembling aspen was injured over an area of about 15 square kilometres. Vegetables in the gardens in this area to the west of the smelter were also severely injured. Beans, beets, peas, carrots, rhubarb, and pumpkin were the most seriously injured.

Trace SO<sub>2</sub> injury was observed on oats in the Chelmsford area about the second week in August. It is believed that the source of the fumigation or fumigations was the Inco smelter.

A fumigation with an intensity of 173 was recorded at the Hanmer station on August 15th. There was a maximum one hour concentration of 1.06 ppm during this fumigation. Trace to light SO<sub>2</sub> injury was evident on oats, barley, and buckwheat following this fumigation. Wind directions collected at the Sudbury airport seem to indicate that this fumigation was the result of the emissions from the two area smelters.

Flowers and vegetables in the Town of Garson were severely damaged by an SO<sub>2</sub> fumigation from the Falconbridge smelter on August 19th. Injury was evident on white birch trees between Garson and Falconbridge.

Conclusions: Atmospheric emissions of sulphur dioxide have been greatly reduced at both the Inco and Falconbridge smelters over the past five years. As would be expected, there has been a corresponding reduction in the levels of SO<sub>2</sub> recorded at the Ministry monitors. While acute vegetation injury by SO<sub>2</sub> is still occurring in the Sudbury area, it has been confined to a much smaller area during the past few years.



VI. Chemical Analysis of Vegetation and Soil Samples (1970-1974):

During the 1970 growing season the Ministry of the Environment established 15 permanent vegetation and soil sampling plots in the territory affected by the Sudbury area smelters and two control plots in areas remote from Sudbury. Since that time, four additional plots have been established at various locations. The following table lists the location of each plot, the year of establishment and the distance and direction of the plot from the city of Sudbury.

<u>Plot Location</u>	<u>Year Established</u>	<u>Distance and Direction from Sudbury</u>
Blind River	1970	160 Km W (Control plot)
Mattawa	1970	176 Km E (Control plot)
Sudbury	1970	Laurentian University
Garson	1970	5 Km NE
Skead	1970	26 Km NE
Kukagami Lake	1970	42 Km NE
Grassy Lake	1970	64 Km NE
Timagami	1970	80 Km NE
Callum	1970	29 Km E
Sturgeon Falls	1970	77 Km E
St. Charles	1970	48 Km SE
Burwash	1970	27 Km SSE
Tilton Lake	1973	15 Km SSW
Lake Penage	1970	37 Km SW
Killarney Park	1972	64 Km SW
Nairn Centre	1970	48 Km WSW
Fairbanks Park	1973	37 Km W
Rayside	1970	16 Km NW
Morgan	1970	24 Km NW
Milnet	1970	37 Km N
Chiniguchi Lake	1973	57 Km NNE



At each station, the current and one-year-old needles of jack pine and the leaves from trembling aspen, white birch, bracken fern and forage, as well as soil (0-10cm), were collected in June, July, August and September of 1970. These samples were analyzed for sulphur, fluoride, arsenic, cobalt, copper, iron, nickel, selenium and zinc. Repeat samples were collected in June, July and August of 1971, 1972 and 1973. These samples were similarly analyzed except that fluoride and selenium were deleted from the list. In 1973 the samples were analyzed for lead. Also calcium and magnesium analysis of the soil was initiated in 1973. In 1974, samples of current and one-year-old needles of jack pine, trembling aspen leaves, forage and soil (0-10 cm) were collected in June, July and August. These samples were analyzed for sulphur, arsenic, copper, iron and nickel. The soil samples were also analyzed for calcium and magnesium. Since five years' data are now available as a result of this surveillance program, the sampling will be reduced to include only trembling aspen and soil in 1975. Also, these samples will be collected in July and August only. This limited sampling will allow the Ministry to monitor changes in the levels of these contaminants in vegetation and soil, while allowing time for the development of more intensive programs on specific problems in the Sudbury area.

At the time of writing this report the full analysis of the 1974 samples was not yet complete. However the 1970 to 1973 data have been compiled and subjected to statistical analysis. The table of analysis of variance (Table 4: P - Values) shows that over the four year period in most instances the levels of the various chemical elements in the different species varied significantly from species to species at the 1% confidence level. This means that the level of a given element in a single species is not comparable to the level of that element in another species.

With regard to the variance from station to station, sulphur and nickel have shown consistent differences over the three year period at the 1% confidence level. Only in 1973 did a significant difference appear for the cobalt analysis, however the actual levels have remained quite low. For copper, a few of the stations closer to Sudbury were significantly higher than some of the more remote stations in 1973. The levels of iron in the foliage generally have shown a decrease since 1972 when several of the sources reduced their volume of output or ceased operations completely. These decreases have resulted in non-significant differences from station-to-station for iron in vegetation. In 1973, the lead levels were not found to be significantly different from station-to-station. The differences in the zinc concentrations from station-to-station at the .1% level are not related to distance from Sudbury but rather to the zinc content of the soil material.

Tables 5 to 10 show the concentrations of the various chemical elements in the different species of vegetation and in soil for the 1970 to 1973 period. As was noted earlier in this report, in 1972 the Falconbridge pyrrhotite plant was shut down; the Inco smelter at Coniston was shut down the sulphur dioxide output from the Inco iron ore recovery

plant was reduced to 250 tons per day; and the new 1250' stack became operational at the Inco Copper Cliff smelter, (August 21st). In 1972 and 1973 both Inco and Falconbridge were closed for 2 or 3 week vacation periods. There were no vacation periods during the 1974 growing season. In very general terms, the levels of sulphur and iron in the vegetation are lower for 1972 and 1973 collections than for the previous two years. This trend is most evident at the Garson, Skead, Kukagami Lake and Grassy Lake stations. The levels of cobalt and lead are low and uniform for all stations. The levels of zinc in the vegetation reflect local soil conditions since these values do not vary directly with distance from the source and indeed some of the levels of zinc in the control samples were higher than those found in vegetation collected closer to the emission sources. With regard to copper in vegetation, the Sudbury and Garson stations remain slightly elevated over the control samples. The nickel levels in vegetation have remained elevated at the Sudbury, Garson, Skead, Kukagami Lake, Callum, Burwash, Tilton Lake and Rayside stations.

The results of the analysis of the soil samples are shown in Tables 11 and 12. Similarly, as with the vegetation analysis, the levels of cobalt, zinc, arsenic and lead are quite low for all sampling stations. In contrast to the vegetation the levels of sulphur in the soil are all very low. It has been our experience that soil sulphur levels are elevated only within close proximity (ie. 2-3 Km) of the smelter stacks. Sulphates are readily leachable through soil profiles into the groundwater and it is felt that this could account for the low levels of this element in the surface soils. With regard to iron, the levels appear to be lower in 1973, than in previous years, however before a trend is predicted the 1974 and 1975 results will have to be studied. Iron is another element which is leached from the upper portion of the soil to lower horizons. The nickel and copper levels remain elevated in the soil at most of the stations. The levels of these elements are especially elevated at Sudbury, Garson, Skead, Kukagami Lake, and Tilton Lake. At Callum and Rayside the levels of these are moderately elevated. Since heavy metals such as copper and nickel have been deposited on Sudbury area soils for a number of years as a result of the smelting operations and since these metals are not readily leachable through the soil profile, the levels of these metals in surface soils will not be readily reduced, in spite of the operational changes which have occurred in recent years. The levels of calcium and magnesium in the soils at the sampling stations were found to be quite low. This means that the buffer capacity of these soils is quite low. This capacity is important for buffering acidic precipitation which lands on the soil surface or sulphuric acid from the smelter plumes which is deposited directly at the point of impingement. The calcium levels at Chiniguchi Lake, Skead, Tilton Lake and Fairbanks Lake are especially low. This apparent lack of buffer capacity is reflected in the pH of the Sudbury area soils as shown in Table 13. The soils of this area are normally acidic as is indicated by the pH of the control samples collected at Blind River and Mattawa. However, the mean pH

value for the majority of soil samples collected at the Sudbury surveillance sampling stations over the four year period are lower than those for the control areas and in general the pH increases with distance from Sudbury. The lowest mean soil pH values were recorded at the Sudbury, Garson, Skead, Rayside, Killarney and Chiniguchi Lake stations. Sudbury, Garson, Rayside and Skead are the areas which have, over the years, had the highest number of SO<sub>2</sub> fumigations. The highest levels of heavy metals in vegetation and soils have also been found at these locations. Killarney is located in an area of quartzite outcroppings of poor buffer capacity and Chiniguchi Lake is located on an ortho-quartzite lorraine, also with a poor buffering capacity.

- VII. Conclusions: The results of the vegetation and soil sampling program over the past five years have shown that there has been some improvement in conditions in the Sudbury area. The levels of sulphur and iron in the vegetation have decreased somewhat since 1972. The levels of copper and nickel remain elevated at some collection stations. It has been found that the levels of arsenic, cobalt and zinc are either low or do not vary directly with distance from the source. In the soil the levels of copper and nickel have remained elevated over the total sampling period.

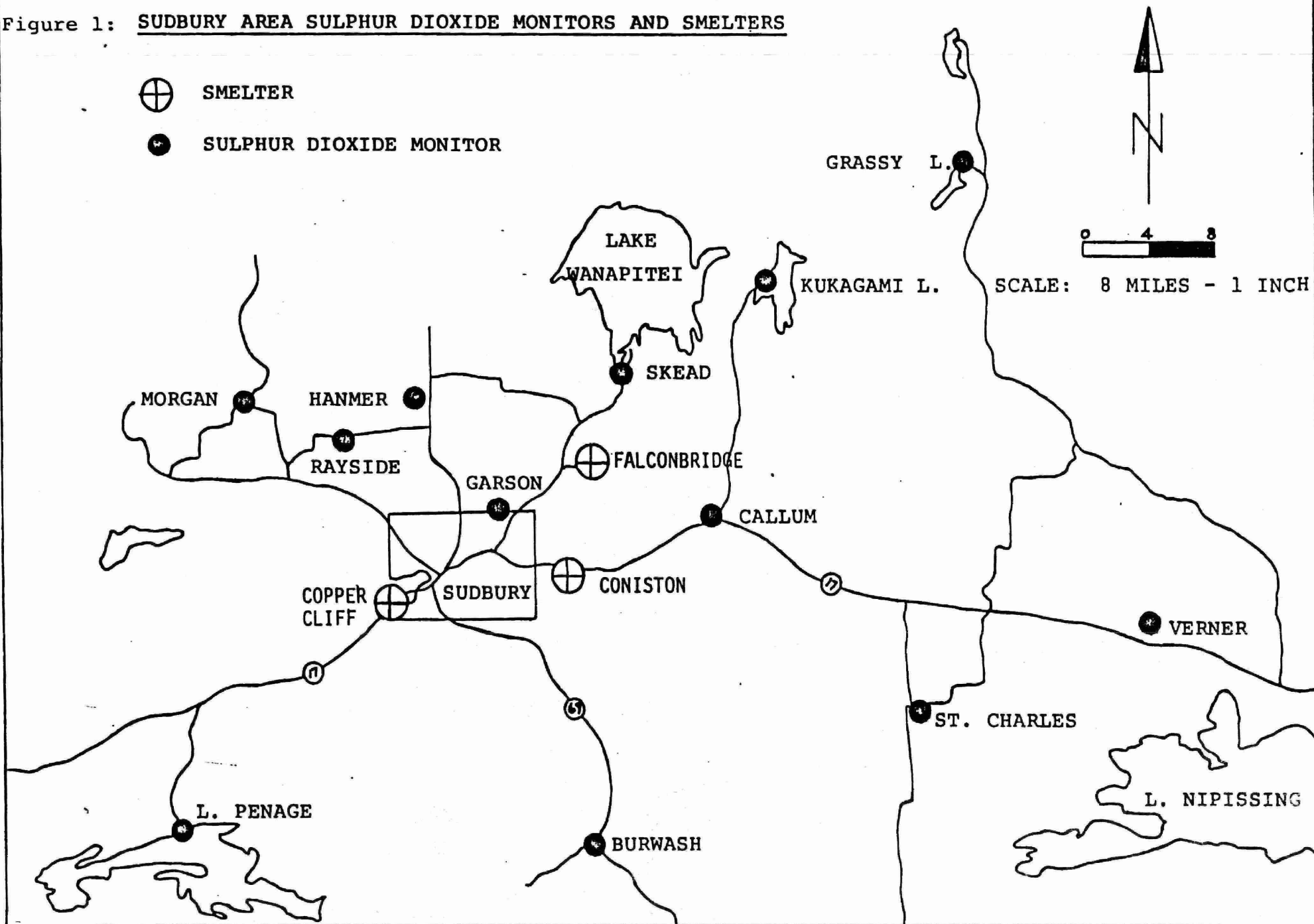
The data collected to date will form the baseline information for judging the performance of the abatement procedures which are already underway at the Falconbridge smelter and are in the planning stages for the Inco smelter at Copper Cliff.

VIII. Acknowledgments:

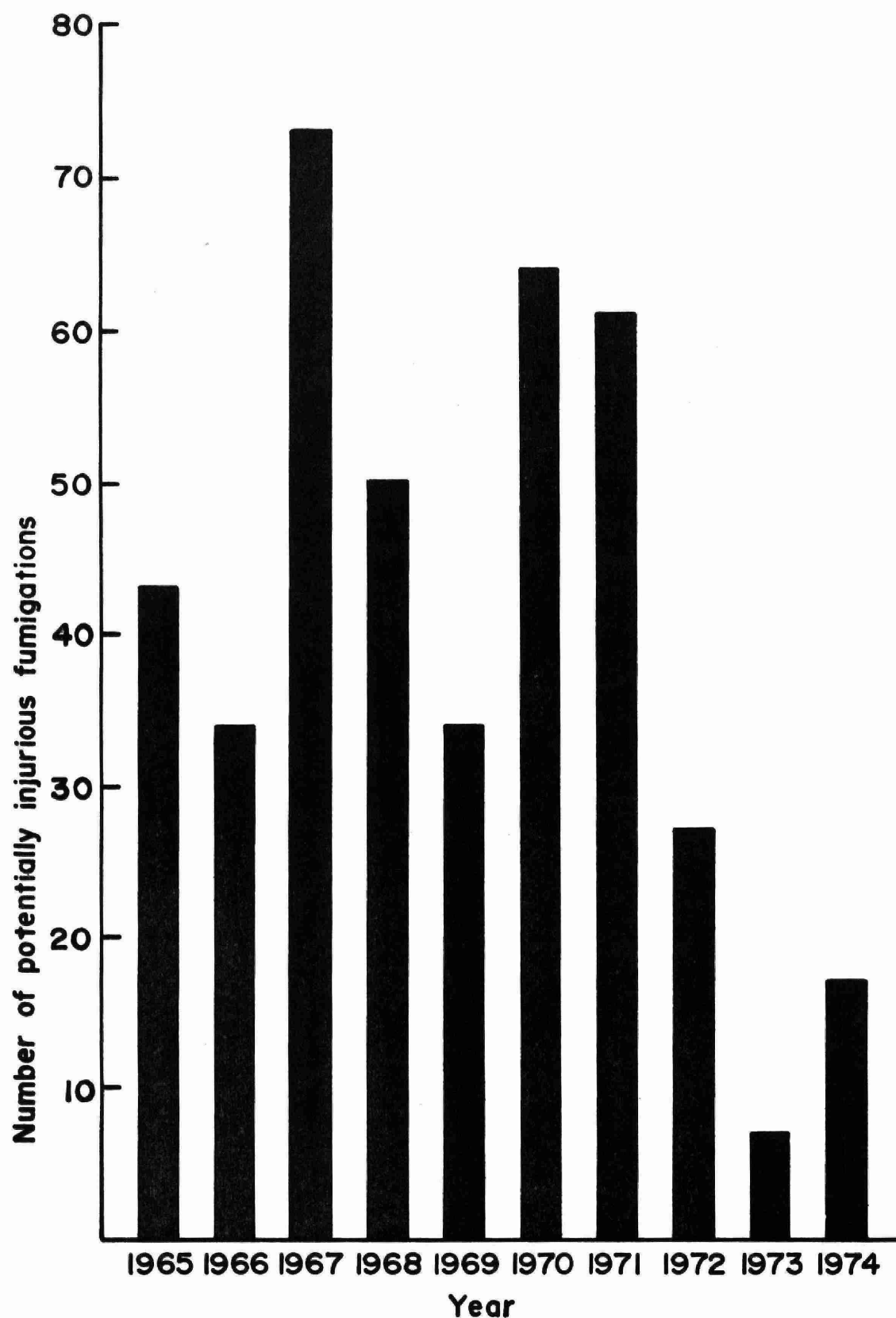
The writers wish to express their gratitude to Dr. S.N. Linzon, Supervisor, Phytotoxicology Section, Air Resources Branch for his advice and supportive services; to Mr. K. Waldie and his staff for maintaining the SO<sub>2</sub> monitors; to Mr. N. Jain for compiling the SO<sub>2</sub> data; to Mr. B. Chai for statistical analysis of the data; to Mr. A. Rayner and Mr. R. Wills and the staff of the Air Quality Laboratory for the analysis of the samples and to Jennifer Hatton, Donna Labre and Edith Forman for secretarial assistance. The contributions and co-operation of these people have made the presentation of this report possible.

I X .      A P P E N D I X

Figure 1: SUDBURY AREA SULPHUR DIOXIDE MONITORS AND SMELTERS



**Fig 2:** Potentially injurious fumigations recorded by Sudbury SO<sub>2</sub> monitors for the years 1965 - 1974.



**Figure 3:**

- Sudbury area Sampling Stations - Vegetation and Soil  
(check stations at Blind River and Mattawa)

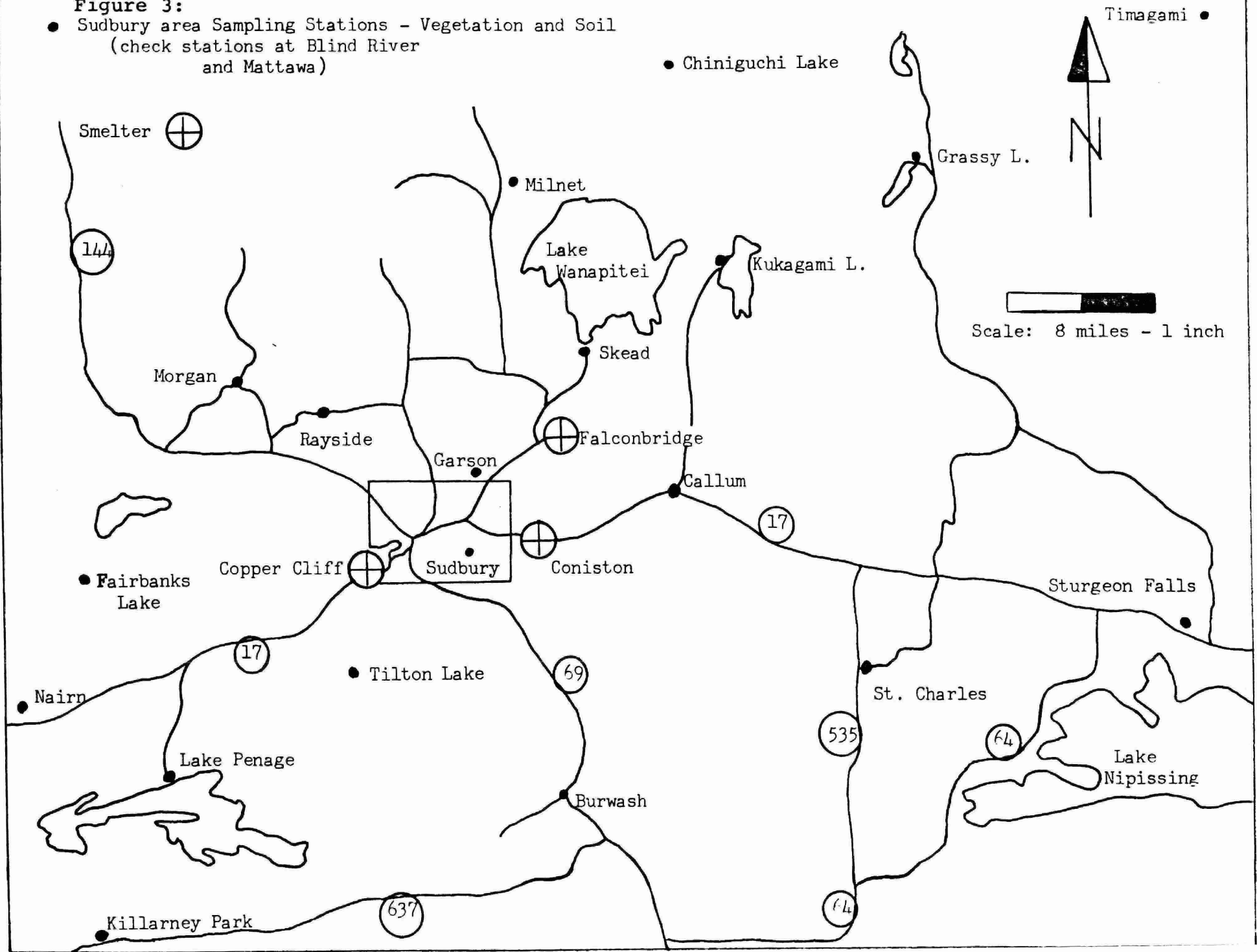


TABLE 1

SUMMARY OF SULPHUR DIOXIDE DATA COLLECTED  
AT SUDBURY AREA MONITORING STATIONS DURING 1974

- M A Y -

STATION	SO <sub>2</sub>		HRS. of SO <sub>2</sub> ABOVE		MAX. 1 HR. CONC. ppm	AVERAGE CONCENTRATION FOR (ppm)					
	HRS.	%	0.25 ppm	0.50 ppm		SO <sub>2</sub> Periods Only			Total Period		
						* Mean	1973	1974	* Mean	1973	1974
Garson	97	13.1	9	1	0.53	0.117	0.056	0.080	0.024	0.012	0.010
Skead	102	14.0	14	3	1.06	0.170	0.063	0.114	0.033	0.024	0.016
Kukagami Lake	68	11.3	1	0	0.34	0.087	0.020	0.053	0.017	0.015	0.006
Grassy Lake	43	10.3	0	0	0.08	0.064	0.026	0.023	0.006	0.005	0.003
Penage	59	8.1	1	0	0.35	0.116	0.020	0.055	0.010	0.004	0.004
Morgan	69	9.4	3	2	0.68	0.035	0.020	0.042	0.007	0.005	0.004
Burwash	74	20.6	1	0	0.26	0.068	0.021	0.043	0.010	0.015	0.008
Rayside	42	5.8	0	0	0.21	0.148	0.031	0.031	0.016	0.008	0.002
St. Charles	93	15.4	0	0	0.05	0.044	0.019	0.016	0.002	0.003	0.002
Callum	117	15.7	2	0	0.31	0.082	0.046	0.033	0.011	0.004	0.005
** Verner	62	8.3	0	0	0.11	-----	0.022	0.016	-----	0.001	0.001
*** Hanmer	109	15.1	7	3	0.82	-----	-----	0.071	-----	-----	0.001

\*\*Data available for three seasons only.

\*\*\*Data available for one season only.

\* Mean is the average for the period 1960-1971,  
excluding 1966 and 1969.



TABLE 1

SUMMARY OF SULPHUR DIOXIDE DATA COLLECTED  
AT SUDBURY AREA MONITORING STATIONS DURING 1974

- J U N E -

STATION	SO <sub>2</sub>		HRS. of SO <sub>2</sub> ABOVE		MAX. 1 HR. CONC. ppm	AVERAGE CONCENTRATION FOR (ppm)					
	HRS.	%	0.25 ppm	0.50 ppm		SO <sub>2</sub> Periods Only			Total Period		
						* Mean	1973	1974	* Mean	1973	1974
Garson	111	15.6	3	0	0.40	0.172	0.081	0.051	0.047	0.014	0.008
Skead	157	23.4	20	6	0.81	0.196	0.044	0.120	0.050	0.025	0.029
Kukagami Lake	70	13.9	0	0	0.18	0.091	0.043	0.050	0.019	0.010	0.007
Grassy Lake	31	6.1	0	0	0.13	0.072	0.025	0.030	0.012	0.005	0.002
Penage	28	3.9	0	0	0.18	0.138	0.032	0.058	0.012	0.002	0.002
Morgan	18	2.6	0	0	0.02	0.070	0.013	0.012	0.004	0.011	0.001
Burwash	32	5.3	0	0	0.04	0.068	0.018	0.013	0.009	0.012	0.001
Rayside	117	16.6	2	0	0.45	0.132	0.037	0.032	0.010	0.012	0.005
St. Charles	90	12.6	0	0	0.13	0.047	0.018	0.024	0.002	0.007	0.003
Callum	80	11.1	3	1	0.70	0.100	0.037	0.051	0.013	0.003	0.006
Verner	5	1.2	0	0	0.10	-----	0.014	0.040	-----	0.001	0.001
Hanmer	152	21.1	11	1	0.59	-----	-----	0.067	-----	-----	0.014

\*\*Data available for three seasons only.

\*\*\*Data available for one season only.

\* Mean is the average for the period 1960-1971,  
excluding 1966 and 1969.

TABLE 1

SUMMARY OF SULPHUR DIOXIDE DATA COLLECTED  
AT SUDBURY AREA MONITORING STATIONS DURING 1974

- J U L Y -

STATION	SO <sub>2</sub>		HRS. of SO <sub>2</sub> ABOVE		MAX. 1 HR. CONC. ppm	AVERAGE CONCENTRATION FOR (ppm)					
	HRS.	%	0.25 ppm	0.50 ppm		SO <sub>2</sub> Periods Only			Total Period		
						* Mean	1973	1974	* Mean	1973	1974
Garson	194	26.3	10	0	0.42	0.143	0.048	0.054	0.031	0.008	0.014
Skead	154	21.5	8	1	0.75	0.183	0.058	0.064	0.042	0.013	0.014
Kukagami Lake	155	28.2	0	0	0.24	0.076	0.028	0.054	0.015	0.005	0.006
Grassy Lake	58	7.8	0	0	0.17	0.060	0.026	0.042	0.007	0.006	0.003
Penage	25	3.5	0	0	0.20	0.092	0.060	0.047	0.003	0.002	0.002
Morgan	120	16.5	0	0	0.03	0.008	0.017	0.013	0.004	0.011	0.002
Burwash	106	18.9	1	0	0.29	0.075	0.022	0.032	0.010	0.007	0.006
Rayside	148	23.6	1	0	0.27	0.158	0.017	0.017	0.010	0.003	0.004
St. Charles	142	19.1	0	0	0.20	0.047	0.017	0.022	0.004	0.005	0.004
Callum	166	22.6	1	0	0.26	0.089	0.041	0.033	0.014	0.006	0.007
** Verner	13	1.8	0	0	0.09	-----	0.012	0.049	-----	0.002	0.001
*** Hanmer	26	3.5	0	0	0.09	-----	-----	0.026	-----	-----	0.001

\*\*Data available for three seasons only.

\*\*\*Data available for one season only.

\* Mean is the average for the period 1960-1971,  
excluding 1966 and 1969.

TABLE 1

SUMMARY OF SULPHUR DIOXIDE DATA COLLECTED  
AT SUDBURY AREA MONITORING STATIONS DURING 1974

- A U G U S T -

STATION	SO <sub>2</sub>		HRS. of SO <sub>2</sub> ABOVE		MAX. 1 HR. CONC. ppm	AVERAGE CONCENTRATION FOR (ppm)					
	HRS.	%	0.25 ppm	0.50 ppm		SO <sub>2</sub> Periods Only			Total Period		
						* Mean	1973	1974	* Mean	1973	1974
Garson	222	30.6	11	0	0.44	0.172	0.033	0.046	0.035	0.002	0.014
Skead	402	54.3	36	13	0.89	0.152	0.048	0.077	0.038	0.011	0.042
Kukagami Lake	44	11.6	0	0	0.16	0.089	0.026	0.046	0.015	0.007	0.005
Grassy Lake	229	31.9	0	0	0.11	0.059	0.021	0.015	0.006	0.004	0.005
Penage	29	4.0	1	0	0.31	0.099	0.023	0.078	0.005	0.002	0.003
Morgan	114	15.5	2	0	0.30	0.060	0.013	0.023	0.003	0.004	0.004
Burwash	52	7.1	0	0	0.18	0.079	0.017	0.032	0.010	0.014	0.002
Rayside	284	34.2	0	0	0.12	0.131	0.021	0.015	0.011	0.004	0.005
St. Charles	130	17.5	0	0	0.22	0.050	0.019	0.025	0.003	0.005	0.004
Callum	97	13.1	4	1	0.90	0.098	0.061	0.060	0.017	0.005	0.008
** Verner	23	4.0	0	0	0.17	-----	0.011	0.041	-----	0.002	0.002
*** Hanmer	181	24.5	10	4	1.06	-----	-----	0.058	-----	-----	0.014

\*\*Data available for three seasons only.

\*\*\*Data available for one season only.

\* Mean is the average for the period 1960-1971,  
excluding 1966 and 1969.

TABLE 1

SUMMARY OF SULPHUR DIOXIDE DATA COLLECTED  
AT SUDBURY AREA MONITORING STATIONS DURING 1974

- S E P T E M B E R -

STATION	SO <sub>2</sub>		HRS. of SO <sub>2</sub> ABOVE		MAX. 1 HR. CONC. ppm	AVERAGE CONCENTRATION FOR (ppm)					
	HRS.	%	0.25 ppm	0.50 ppm		SO <sub>2</sub> Periods Only			Total Period		
						* Mean	1973	1974	* Mean	1973	1974
Garson	186	26.2	6	0	0.46	0.148	0.034	0.029	0.026	0.003	0.007
Skead	178	24.9	26	2	0.64	0.197	0.039	0.110	0.047	0.007	0.027
Kukagami Lake	30	8.3	1	0	0.26	0.096	0.048	0.074	0.014	0.006	0.006
Grassy Lake	165	28.1	0	0	0.14	0.063	0.016	0.017	0.006	0.006	0.005
Penage	3	0.4	0	0	0.03	0.106	0.010	0.020	0.006	0.002	0.001
Morgan	131	23.2	0	0	0.10	0.065	0.012	0.012	0.005	0.002	0.003
Burwash	61	8.8	1	0	0.35	0.085	0.030	0.026	0.009	0.007	0.005
Rayside	192	26.8	0	0	0.25	0.148	0.024	0.018	0.017	0.003	0.005
St. Charles	74	12.8	0	0	0.19	0.047	0.023	0.028	0.004	0.004	0.004
Callum	70	9.8	5	1	0.74	0.097	0.055	0.087	0.014	0.004	0.009
** Verner	32	4.7	0	0	0.15	—	0.014	0.022	—	0.002	0.001
*** Hanmer	245	35.6	3	1	0.64	—	—	0.030	—	—	0.010

\*\*Data available for three seasons only.

\*\*\*Data available for one season only.

\* Mean is the average for the period 1960-1971,  
excluding 1966 and 1969.

TABLE 1

SUMMARY OF SULPHUR DIOXIDE DATA COLLECTED  
AT SUDBURY AREA MONITORING STATIONS DURING 1974

- O C T O B E R -

STATION	SO <sub>2</sub>		HRS. of SO <sub>2</sub> ABOVE		MAX. 1 HR. CONC. ppm	AVERAGE CONCENTRATION FOR (ppm)					
	HRS.	%	0.25 ppm	0.50 ppm		SO <sub>2</sub> Periods Only			Total Period		
						* Mean	1973	1974	* Mean	1973	1974
Garson	115	15.5	5	2	0.65	0.146	0.031	0.040	0.025	0.002	0.006
Skead	139	18.8	22	6	0.69	0.211	0.053	0.011	0.045	0.017	0.016
Kukagami Lake	2	20.0	2	1	0.84	0.100	0.044	0.565	0.014	0.006	0.113
Grassy Lake	107	15.1	3	1	0.61	0.069	0.016	0.038	0.007	0.005	0.006
Penage	25	3.4	0	0	0.10	0.108	0.020	0.027	0.006	0.001	0.009
Morgan	24	4.0	0	0	0.02	0.068	0.022	0.012	0.007	0.004	0.001
Burwash	110	14.9	3	0	0.38	0.018	0.016	0.052	0.010	0.002	0.008
Rayside	84	11.7	1	0	0.26	0.112	0.065	0.043	0.014	0.010	0.005
St. Charles	87	12.0	3	0	0.16	0.056	0.013	0.023	0.004	0.002	0.003
Callum	115	15.5	5	0	0.40	0.095	0.030	0.047	0.012	0.003	0.007
** Verner	12	2.3	0	0	0.14	-----	0.014	0.057	-----	0.004	0.001
*** Hanmer	151	20.4	2	0	0.30	-----	-----	0.029	-----	-----	0.006

\*\*Data available for three seasons only.

\*\*\*Data available for one season only.

\* Mean is the average for the period 1960-1971,  
excluding 1966 and 1969.

TABLE 2  
SUMMARY OF SULPHUR DIOXIDE DATA  
COLLECTED AT SUDBURY AREA MONITORS  
DURING 1974 (May - October)

STATION	% VALID DATA	TOTAL # OF READINGS	SO <sub>2</sub> READINGS
Garson	99%	4364	925
Skead	97%	4300	1132
Kukagami Lake	43%	2406	369
Grassy Lake	81%	3681	633
Lake Penage	99%	4361	169
Morgan	91%	4073	476
Burwash	83%	3699	435
Rayside	95%	4217	833
St. Charles	93%	4109	616
Callum	99%	4391	645
Verner	90%	3679	147
Hanmer	98%	4349	864
TOTAL		47,629	7244

TABLE 3  
POTENTIALLY INJURIOUS FUMIGATIONS  
RECORDED DURING MAY - OCTOBER, 1974

STATION	NUMBER OF POTENTIALLY INJURIOUS FUMIGATIONS	DATES	INTENSITY
Garson	2	September 5 October 3	104 134
Skead	9	May 12 June 4 June 19 June 27 August 15 August 21 September 27 September 28 October 28	183 124 109 120 134 124 118 114 122
Kukagami Lake	1	October 3	103
Grassy Lake	0	---	---
Penage	0	---	---
Morgan	1	May 20	122
Burwash	0	---	---
Rayside	0	---	---
St. Charles	0	---	---
Callum	1	August 30	111
Verner	0	---	---
Hanmer	3	May 2 August 15 August 20	177 173 103
TOTAL	17		

Table 4:

Summary of Analysis of Variance (P-Values)  
For Several Elements in Vegetation in the Sudbury Area  
1970-1973

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<u>Source of Variance</u>	<u>Year</u>	<u>Sulphur</u>	<u>Cobalt</u>	<u>Copper</u>	<u>Iron</u>	<u>Nickel</u>	<u>Lead</u>	<u>Zinc</u>
<u>Species</u>	1970	.001	NS	.001	.05	.001	--	.001
	1971	.001	.001	.001	.001	.001	--	.001
	1972	.001	.001	.1	.1	.001	--	.001
	1973	.001	.001	.001	NS	.001	NS	.001
<u>Stations</u>	1970	.001	NS	.001	.001	.001	--	.01
	1971	.001	NS	.1	.001	.001	--	.05
	1972	.001	NS	.1	.1	.001	--	.001
	1973	.001	.01	.01	NS	.001	NS	.001

P = NS Not Significant at 10% Level

P = .1 Significant at 10% Level

P = .05 Significant at 5% Level

P = .01 Significant at 1% Level

P = .001 Significant at .1% Level



Table 5: Concentrations of the Various Chemical Elements in the Jack Pine Foliage (Current Year)  
Collected at the Sudbury Surveillance Plots During the 1970, 1971, 1972 and 1973  
Growing Seasons (Average of Four 1970 and Three (1971, 1972, 1973) Monthly  
Collections)

		CHEMICALS																								
Plot	*Location	To S%				Co ppm				Cu ppm				Fe ppm				Ni ppm				Zn ppm				Pb ppm
		1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1973
Blind River	160 km W	.10	.11	.11	.10	2	5	1	3	2	5	6	4	24	47	32	34	2	14	5	3	66	70	47	58	4
Mattawa	176 km E	.12	.11	.12	.12	2	2	1	2	5	5	7	4	36	54	43	58	3	6	8	3	74	66	74	77	4
Sudbury	Laurentian	.14	.14	.15	.11	2	5	3	2	9	9	21	8	47	111	62	58	26	28	40	37	53	24	25	25	12
Milnet	37 km N.	.14	.12	.14	.16	2	5	1	2	18	6	7	4	84	76	52	60	25	19	29	30	55	40	46	53	5
Chiniguchi L.	57 km NNE	--	--	--	.17	-	-	-	2	-	-	-	3	--	--	--	50	--	--	--	18	--	--	--	39	5
Garson	5 km NE	--	--	--	--	-	-	-	-	-	-	-	-	--	--	--	--	--	--	--	--	--	--	--	--	-
Skead	26 km NE	.22	.23	.22	.19	2	4	2	2	28	18	12	19	306	403	99	102	60	45	54	37	29	27	23	29	5
Kukagami L.	42 km NE	.19	.18	.17	.13	2	6	2	6	15	8	9	8	118	91	69	71	39	23	50	25	29	52	37	37	2
Grassy L.	64 km NE	.11	.14	.15	.11	2	3	2	5	6	7	12	7	60	60	49	43	16	22	23	20	44	43	50	48	3
Temagami	80 km NE	.14	.17	.16	.10	2	3	2	5	12	5	9	5	97	115	71	72	18	13	21	20	74	62	48	49	5
Callum	29 km E	.16	.14	.14	.13	2	5	1	3	9	8	7	6	52	75	44	53	32	34	34	28	20	30	47	30	5
Sturgeon Falls	77 km E	--	.13	.18	.10	-	2	2	1	-	7	5	5	--	90	41	49	--	10	10	9	--	68	52	52	2
St. Charles	48 km SE	.10	.13	.14	.13	2	3	2	3	5	7	8	6	64	173	58	53	9	12	19	28	47	44	42	30	5
Burwash	27 km S	.12	.14	.14	.12	2	3	1	2	6	6	10	5	70	128	72	70	22	17	29	28	30	38	35	33	5
Tilton L.	15 km SW	--	--	--	--	-	-	-	-	-	-	-	-	--	--	--	--	--	--	--	--	--	--	--	--	-
Penage	37 km SW	.13	.16	.12	--	2	4	2	-	8	10	9	-	294	105	40	--	39	11	20	--	30	55	26	--	-
Killarney Park	64 km SW	--	--	--	.08	-	-	-	2	-	-	-	6	--	--	--	65	--	--	--	30	--	--	--	46	3
Nairn Centre	48 km WSW	.12	.11	.13	.11	2	3	2	5	3	6	8	4	40	61	46	49	14	15	15	17	46	64	52	55	6
Fairbanks L.	37 km W	--	--	--	.11	-	-	-	3	-	-	-	4	--	--	--	34	--	--	--	20	--	--	--	45	2
Rayside	16 km NW	.14	.14	.13	.12	2	5	2	1	13	6	6	7	113	351	82	74	40	30	41	37	23	33	42	41	5
Morgan	24 km NW	.15	.23	.14	.11	2	11	2	2	8	4	7	4	91	180	77	84	15	26	28	25	40	88	40	41	5

\*Distance and Direction From Sudbury  
Blind River and Mattawa are Control Plots (Washed Samples)

Table 6: Concentrations of the Various Chemical Elements in the Jack Pine Foliage (One year old)  
 Collected at the Sudbury Surveillance Plots During the 1970, 1971, 1972 and 1973  
 Growing Seasons (Average of Four 1970 and Three (1971, 1972, 1973) Monthly  
 Collections)

		CHEMICALS																								
Plot	*Location	To S%				Co ppm				Cu ppm				Fe ppm				Ni ppm				Zn ppm				Pb ppm
		1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1973
Blind River	160 km W	.07	.08	.10	.08	2	3	2	3	2	5	3	3	35	43	56	54	1	6	3	2	92	47	44	48	3
Mattawa	176 km E	.09	.10	.13	.09	2	3	2	1	6	4	5	2	62	84	87	88	6	3	3	2	83	92	105	95	6
Sudbury	Laurentian	.14	.21	.17	.13	2	5	3	2	21	13	35	12	191	305	254	180	36	35	44	41	17	23	25	19	3
Milnet	37 km N.	.14	.14	.13	.13	2	3	2	2	34	11	9	5	105	150	124	129	34	17	18	24	48	40	45	49	12
Chiniguchi L.	57 km NNE	--	--	--	.11	-	-	-	2	--	--	--	4	---	---	---	70	--	--	--	9	--	--	--	25	6
Garson	5 km NE	--	--	--	--	-	-	-	-	--	--	--	-	---	---	---	---	--	--	--	--	--	--	--	--	-
Skead	26 km NE	.26	.22	.21	.17	2	2	2	2	55	26	25	29	503	784	419	211	55	44	48	55	15	28	18	51	17
Kukagami L.	42 km NE	.18	.17	.14	.13	2	5	1	3	35	8	14	11	239	197	219	160	35	17	37	27	40	43	38	34	7
Grassy L.	64 km NE	.09	.13	.12	.09	2	4	2	5	9	6	6	7	93	91	110	91	9	11	13	12	33	41	45	40	3
Temagami	80 km NE	.10	.15	.14	.10	2	2	2	3	10	4	6	5	132	183	181	149	10	8	13	13	52	68	44	55	4
Callum	29 km E	.12	.15	.17	.10	2	4	2	2	15	10	11	8	125	162	100	139	37	31	34	26	28	25	45	18	7
Sturgeon Falls	77 km E	--	.14	.13	.09	-	5	2	2	--	7	8	5	---	119	119	96	--	12	8	8	--	5	71	71	2
St. Charles	48 km SE	.12	.14	.17	.11	2	4	2	4	6	7	8	5	99	259	165	112	5	10	11	9	45	38	40	37	5
Burwash	27 km S	.16	.17	.21	.14	2	3	2	2	11	7	10	5	118	169	167	121	17	18	20	16	31	44	44	30	12
Tilton L.	15 km SW	--	--	--	--	-	-	-	-	--	-	--	-	--	---	---	---	--	--	--	--	--	--	--	--	--
Penage	37 km SW	.13	.13	.16	--	2	8	2	-	17	7	5	-	56	118	50	---	8	8	12	--	46	13	26	--	-
Killarney Park	64 km SW	--	--	--	.08	-	-	-	1	--	-	-	6	---	---	--	122	--	--	--	26	--	--	--	84	4
Nairn Centre	48 km WSW	.12	.14	.14	.11	2	4	2	5	10	6	5	5	69	112	98	106	6	12	10	9	55	78	60	46	7
Fairbanks L.	37 km W	--	--	--	.10	-	-	-	3	--	-	-	6	--	---	---	72	--	--	--	24	--	--	--	37	4
Rayside	16 km NW	.12	.11	.14	.11	2	4	4	1	38	10	10	8	141	206	174	210	38	29	28	32	24	31	29	29	6
Morgan	24 km NW	.12	.15	.14	.10	2	3	2	2	17	9	7	4	119	262	152	133	13	16	21	21	33	40	36	41	5

\*Distance and Direction From Sudbury  
 Blind River and Mattawa are Control Plots (Washed Samples)

TABLE 7:

CONCENTRATIONS OF THE VARIOUS CHEMICAL ELEMENTS IN THE TREMBLING ASPEN FOLIAGE  
Collected at the Sudbury Surveillance Plots During the 1970, 1971, 1972 and 1973  
Growing Seasons (Average of Four 1970 and Three (1971, 1972, 1973) Monthly  
Collections)

## CHEMICALS

Plot	*Location	To S%				Co ppm				Cu ppm				Fe ppm				Ni ppm				Zn ppm				Pb ppm
		1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1973
Blind River	160 km W	.16	.22	.18	.20	2	10	3	3	6	10	13	10	45	62	49	45	3	6	5	2	283	265	209	258	3
Mattawa	176 km E	.19	.22	.19	.19	2	5	3	2	11	8	10	9	62	81	53	64	3	5	7	4	262	212	257	242	4
Sudbury	Laurentian	.33	.42	.23	.21	1	12	9	4	17	14	9	8	125	362	69	76	54	136	73	94	84	124	93	89	11
Milnet	37 km N.	.26	.27	.24	.25	3	6	4	3	23	9	9	8	159	94	99	107	78	20	38	33	238	141	250	152	7
Chiniguchi L.	57 km NNE	---	---	---	.26	-	-	-	7	---	---	---	6	---	---	---	85	---	---	---	42	---	---	---	178	7
Garson	5 km NE	.44	.49	.30	.37	4	6	5	7	27	29	14	14	144	317	69	75	99	59	82	128	75	125	88	69	5
Skead	26 km NE	.37	.50	.31	.39	4	6	4	5	38	15	15	15	437	242	283	137	83	76	57	68	176	141	188	175	8
Kukagami L.	42 km NE	.40	.36	.33	.29	3	11	3	6	22	12	14	14	184	173	183	163	45	58	53	53	225	187	163	204	6
Grassy L.	64 km NE	.22	.40	.24	.19	2	12	5	10	10	10	10	10	69	101	45	67	18	16	21	18	163	152	115	135	4
Temagami	80 km NE	.33	.37	.31	.21	2	6	4	3	21	11	14	13	159	317	150	152	15	13	18	14	109	202	414	317	5
Callum	29 km E	.27	.43	.29	.24	4	13	6	8	14	12	9	10	98	150	71	168	96	105	103	78	131	280	152	136	8
Sturgeon Falls	77 km E	.18	.33	.23	.19	2	10	4	2	10	11	10	11	45	130	88	108	9	9	7	9	570	262	245	295	5
St. Charles	48 km SE	.20	.29	.18	.17	3	11	3	4	15	9	8	9	124	175	92	77	12	17	16	21	171	217	116	175	4
Burwash	27 km S	.32	.31	.31	.26	2	7	6	2	21	11	12	8	173	178	180	117	36	62	55	36	125	232	120	122	8
Tilton L.	15 km SW	---	---	---	.29	-	-	-	4	---	---	---	10	---	---	---	99	---	---	---	121	---	---	---	204	2
Penage	37 km SW	.23	.32	.34	.23	3	9	6	7	19	10	15	9	74	98	63	88	28	13	28	41	191	130	248	199	5
Killarney Park	64 km SW	---	---	.25	.18	-	-	5	4	---	---	9	9	---	---	51	71	---	---	9	7	---	---	222	272	7
Nairn Centre	48 km WSW	.21	.25	.23	.19	3	8	5	5	11	11	14	10	81	102	67	85	15	17	15	15	265	233	194	257	8
Fairbanks L.	37 km W	---	---	---	.16	-	-	-	4	---	---	---	8	---	---	---	53	---	---	---	41	---	---	---	305	3
Rayside	16 km NW	.20	.26	.24	.27	5	6	7	5	28	10	11	10	167	286	176	191	95	73	90	101	127	111	163	144	7
Morgan	24 km NW	.20	.25	.26	.19	2	6	6	4	17	9	14	9	188	132	105	212	28	31	38	31	156	215	161	200	6

\*Distance and Direction From Sudbury

Blind River and Mattawa are Control Plots (Washed Samples)

Table 8: Concentrations of the Various Chemical Elements in the White Birch Foliage  
Collected at the Sudbury Surveillance Plots During the 1970, 1971, 1972 and 1973  
Growing Seasons (Average of Four 1970 and Three (1971, 1972, 1973) Monthly  
Collections)

		CHEMICALS																								
Plot	*Location	To S%				Co ppm				Cu ppm				Fe ppm				Ni ppm				Zn ppm				Pb ppm
		1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1973
Blind River	160 km W	.12	.14	.13	.14	2	10	4	3	8	7	9	9	54	97	79	81	3	8	7	4	296	607	337	279	6
Mattawa	176 km E	.17	.13	.16	.16	2	5	3	3	10	6	9	8	54	74	51	101	3	5	5	4	270	157	298	356	6
Sudbury	Laurentian	.29	.35	.25	.18	3	6	5	4	26	23	25	19	162	311	163	152	58	81	82	77	90	84	61	108	10
Milnet	37 km N.	.25	.15	.25	.21	2	4	3	2	26	9	8	10	141	147	157	196	42	16	25	19	158	150	172	251	4
Chiniguchi L.	57 km NNE	--	--	--	.21	-	-	-	3	--	--	--	6	---	---	---	94	--	--	--	20	---	---	---	169	9
Garson	5 km NE	.41	.48	.30	.25	2	3	3	3	61	48	24	26	235	360	136	183	84	81	61	86	114	66	80	87	5
Shead	26 km NE	.37	.36	.30	.32	2	5	5	3	59	25	14	29	423	342	229	170	97	72	76	72	188	129	100	147	6
Kukagami L.	42 km NE	.27	.29	.21	.22	2	5	3	5	39	14	10	12	321	133	79	108	46	25	47	16	213	160	116	175	3
Grassy L.	64 km NE	.18	.24	.16	.16	2	5	4	5	11	10	13	10	103	95	85	88	13	11	16	11	237	143	208	169	4
Temagami	80 km NE	.22	.21	.19	.15	2	6	3	3	20	11	13	11	137	345	150	171	14	10	16	10	151	250	174	219	6
Callum	29 km E	.24	.33	.20	.19	2	7	2	3	23	14	9	11	125	187	139	137	44	45	44	47	125	210	124	137	7
Sturgeon Falls	77 km E	.17	.19	.18	.14	2	6	3	3	12	8	9	9	44	122	121	106	7	8	8	7	291	235	209	204	6
St. Charles	48 km SE	.15	.20	.15	.12	2	8	2	4	16	8	7	9	110	176	109	99	16	13	8	11	239	207	168	204	4
Burwash	27 km S	.26	.23	.26	.17	2	4	3	2	23	12	12	11	186	156	125	171	31	25	31	32	76	287	137	148	10
Tilton L.	15 km SW	--	--	--	.17	-	-	-	2	--	--	--	15	---	---	---	161	--	--	--	58	---	---	---	193	14
Penage	37 km SW	.17	.21	.23	.18	2	4	4	4	22	9	13	7	74	71	93	81	13	10	19	16	176	237	173	255	6
Killarney Park	64 km SW	--	--	.18	.14	-	-	3	2	--	--	9	8	--	--	75	90	--	--	10	7	---	---	246	150	8
Nairn Centre	48 km WSW	.17	.18	.19	.15	2	8	4	3	10	11	13	10	75	92	85	92	8	13	12	8	223	349	216	324	11
Fairbanks L.	37 km W	--	--	--	.14	-	-	-	4	--	--	--	7	---	--	---	67	--	--	--	15	---	---	---	216	5
Rayside	16 km NW	.24	.22	.19	.24	2	4	3	2	24	21	13	14	130	447	152	173	45	40	48	59	87	188	158	175	6
Morgan	24 km NW	.17	.31	.22	.17	2	5	4	2	19	16	13	8	140	267	215	151	18	23	19	13	205	280	166	179	6

\*Distance and Direction From Sudbury  
Blind River and Mattawa are Control Plots (Washed Samples)

Table 9: CONCENTRATIONS OF THE VARIOUS CHEMICAL ELEMENTS IN THE BRACKEN FERN FOLIAGE  
 Collected at the Sudbury Surveillance Plots During the 1970, 1971, 1972 and 1973  
 Growing Seasons (Average of Four 1970 and Three (1971, 1972, 1973) Monthly  
 Collections)

		CHEMICALS																								
Plot	*Location	To S%				Co ppm				Cu ppm				Fe ppm				Ni ppm				Zn ppm				Pb ppm
		1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1973
Blind River	160 km W	.10	.13	.18	.19	2	7	2	2	3	6	10	3	61	83	80	65	1	6	6	5	29	32	51	40	6
Mattawa	176 km E	.14	.14	.18	.15	2	4	5	1	9	6	8	6	77	91	73	98	2	4	4	2	51	47	43	48	8
Sudbury	Laurentian	.21	.22	.25	.20	2	8	4	2	21	20	20	15	115	181	96	79	66	30	74	52	54	25	33	35	11
Milnet	37 km N.	.16	.18	.25	.23	2	4	2	2	13	7	16	8	112	116	95	97	20	10	18	19	30	23	40	90	6
Chiniguchi L.	57 km NNE	---	---	---	.17	-	-	-	4	--	--	--	7	---	---	--	75	--	--	--	14	--	--	--	33	9
Garson	5 km NE	.22	.31	.26	.19	2	5	2	3	24	20	25	23	160	212	105	92	67	24	38	47	29	34	24	32	10
Skead	26 km NE	.26	.28	.18	.18	2	6	2	3	17	14	9	10	211	200	75	118	36	27	18	18	24	40	41	34	7
Kukagami L.	42 km NE	.19	.30	.21	.18	2	10	3	3	10	10	9	7	108	144	69	63	24	42	14	40	33	20	28	24	6
Grassy L.	64 km NE	.14	.19	.18	.18	2	4	3	4	6	9	9	11	99	168	78	64	3	6	7	7	29	26	29	32	3
Temagami	80 km NE	.15	.16	.14	.17	2	6	3	3	13	9	8	10	162	267	112	149	6	8	8	7	34	41	40	37	5
Callum	29 km E	.18	.30	.21	.18	2	8	2	5	20	9	8	10	182	116	81	111	42	18	35	27	21	25	60	30	5
Sturgeon Falls	77 km E	.12	.19	.15	.13	2	7	3	3	4	8	5	7	65	141	104	92	2	9	5	5	35	69	27	38	5
St. Charles	48 km SE	.13	.14	.16	.14	2	7	2	4	8	8	16	7	152	123	80	65	6	8	7	5	29	29	42	31	3
Burwash	27 km S	.19	.28	.23	.19	2	8	2	3	20	8	16	10	164	124	96	120	23	5	35	39	28	26	35	34	7
Tilton L.	15 km SW	---	---	---	.14	-	-	-	2	--	--	--	15	---	---	--	99	--	--	--	38	--	--	--	58	13
Penage	37 km SW	.14	.16	.18	.20	2	4	3	5	9	6	14	5	106	128	96	65	9	5	7	5	38	21	54	51	4
Killarney Park	64 km SW	---	---	.18	.14	-	-	2	2	--	--	8	7	---	---	70	85	--	--	5	11	--	--	50	46	7
Nairn Centre	48 km WSW	.13	.19	.19	.21	2	7	3	3	2	7	12	9	102	91	60	87	9	10	9	9	33	51	33	37	8
Fairbanks L.	37 km W	---	---	---	.12	-	-	-	4	--	--	--	5	---	---	--	52	--	--	--	5	--	--	--	26	3
Rayside	16 km NW	.21	.21	.25	.13	2	5	3	1	16	11	11	12	136	169	88	94	51	29	41	48	26	33	32	41	7
Morgan	24 km NW	.20	.18	.18	.22	2	4	3	2	8	7	9	10	103	128	77	118	7	6	10	12	19	33	36	44	7

\*Distance and Direction From Sudbury  
 Blind River and Mattawa are Control Plots (Washed Samples)

Table 10: CONCENTRATIONS OF THE VARIOUS CHEMICAL ELEMENTS IN THE FORAGE SAMPLES  
Collected at the Sudbury Surveillance Plots During the 1970, 1971, 1972 and 1973  
Growing Seasons (Average of Four 1970 and Three (1971, 1972, 1973) Monthly  
Collections)

CHEMICALS

Plot	*Location	To S%				Co ppm				Cu ppm				Fe ppm				Ni ppm				Zn ppm				Pb ppm
		1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1973
Blind River	160 km W	.14	.19	.18	.13	2	3	2	1	9	5	8	5	40	70	79	80	2	2	5	3	29	28	23	43	4
Mattawa	176 km E	.20	.15	.09	.18	2	5	3	3	9	6	2	3	100	122	158	82	3	8	4	3	36	43	25	28	4
Sudbury	Laurentian	.22	.22	.19	.17	2	9	3	2	18	7	17	7	121	291	69	67	24	34	51	36	20	37	18	14	12
Milnet	37 km N.	.30	.28	.31	.25	2	4	2	2	15	10	18	6	98	98	151	287	37	3	10	16	36	43	34	28	6
Chiniguchi L.	57 km NNE	---	---	---	.25	-	-	-	2	---	---	---	5	---	---	---	121	---	---	---	10	---	---	---	39	7
Garson	5 km NE	.40	.28	.37	.16	2	4	3	2	35	12	58	11	122	267	262	122	15	36	65	22	20	21	24	18	6
Skead	26 km NE	.41	.40	.30	.39	2	3	2	3	36	12	19	10	234	281	241	126	33	29	36	36	42	17	21	32	5
Kukagami L.	42 km NE	.31	.31	.34	.19	2	5	2	2	18	11	15	7	112	237	87	114	22	20	7	8	40	42	26	19	4
Grassy L.	64 km NE	.28	.34	.20	.16	2	4	1	4	12	12	6	6	73	95	155	107	6	7	8	7	35	32	25	37	8
Temagami	80 km NE	.19	.18	.17	.15	2	5	2	2	12	7	4	5	148	453	163	193	3	11	7	7	27	21	16	25	4
Callum	29 km E	.25	.25	.22	.22	2	5	2	3	16	8	9	6	110	134	119	183	30	29	49	22	29	39	28	20	3
Sturgeon Falls	77 km E	.14	.31	.16	.16	2	5	3	2	11	9	5	7	82	268	63	98	3	9	5	4	25	42	18	24	3
St. Charles	48 km SE	.22	.19	.21	.16	2	4	3	3	10	5	5	4	97	141	119	84	7	14	11	10	27	22	24	25	3
Burwash	27 km S	.25	.24	.30	.17	2	4	2	3	17	8	3	5	108	376	70	106	20	13	21	24	22	33	32	20	4
Tilton L.	15 km SW	---	---	---	.15	-	-	-	2	---	-	---	7	---	---	---	118	---	---	---	24	---	---	---	20	8
Penage	37 km SW	.23	.21	.18	.25	2	4	2	4	19	8	12	6	79	85	147	54	7	15	15	9	19	48	35	32	12
Killarney Park	64 km SW	---	---	.17	.18	-	-	2	2	---	-	8	10	---	---	62	133	---	---	10	13	---	---	34	46	4
Nairn Centre	48 km WSW	.19	.22	.19	.15	2	4	1	3	8	8	5	7	59	96	46	93	5	10	9	6	19	31	19	30	8
Fairbanks L.	37 km W	---	---	---	.06	-	-	-	4	---	-	---	3	---	---	---	31	---	---	---	7	---	---	---	12	4
Rayside	16 km NW	.27	.26	.23	.23	2	2	2	1	14	7	20	6	139	278	240	88	30	29	36	29	22	25	30	25	5
Morgan	24 km NW	.29	.26	.24	.22	2	5	3	2	13	9	17	7	115	346	174	214	19	5	30	8	29	36	31	29	5

\*Distance and Direction From Sudbury  
Blind River and Mattawa are Control Plots (Not-Washed Samples)

TABLE 11:

CONCENTRATIONS OF THE VARIOUS CHEMICAL ELEMENTS IN THE SOIL SAMPLES  
COLLECTED AT THE SUDBURY SURVEILLANCE PLOTS DURING THE 1970, 1971, 1972 and  
1973 GROWING SEASONS (AVERAGE OF TWO MONTHLY COLLECTIONS)

PLOT	*LOCATION	CHEMICALS													Mg ppm 1973	Pb ppm 1973
		Zn ppm				Co ppm				As ppm				Ca ppm		
		1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1973		
BLIND RIVER	160 Km W	37	42	37	37	6	5	6	15	1.7	4.4	2.2	2.3	269	701	14
MATTAWA	176 Km E	28	37	20	16	2	5	4	5	2.3	3.8	2.9	.9	179	363	ND
SUDBURY	Laurentian	30	93	43	27	9	9	13	11	10.2	18.4	12.4	8.7	159	1973	25
MILNET	37 Km N	40	34	32	10	6	4	17	4	7.2	4.8	3.0	5.9	135	1040	ND
CHINIGUCHI L.	57 Km NNE	--	--	--	15	-	-	-	40	---	---	---	3.9	62	700	ND
GARSON	5 Km NE	23	64	11	20	8	5	8	6	9.8	26.0	7.6	10.4	162	1230	8
SKEAD	26 Km NE	85	77	34	34	9	11	10	10	13.1	47.0	43.7	8.9	30	299	46
KUKAGAMI L.	42 Km NE	43	44	26	38	7	11	13	10	11.7	6.4	13.4	6.3	107	882	10
GRASSY L.	64 Km NE	114	72	43	38	20	13	10	6	7.0	6.6	11.4	5.9	323	884	23
TEMAGAMI	80 Km NE	53	52	35	17	10	7	13	7	4.0	7.0	8.0	2.4	173	1063	11
CALLUM	29 Km E	49	89	33	42	9	8	20	9	11.0	7.7	3.2	2.6	311	1120	13
STURGEON FALLS	77 Km E	72	174	75	72	7	8	13	8	5.6	5.6	4.4	2.5	1288	1360	18
ST. CHARLES	48 Km SE	45	108	103	31	6	8	8	8	7.3	6.5	3.2	2.6	311	1120	13
BURWASH	27 Km S	32	69	20	18	8	7	10	7	3.4	6.7	5.8	3.2	188	1255	4
TILTON L	15 Km SW	--	--	--	52	-	-	--	10	---	---	---	85	42	697	19
PENAGE	37 Km SW	173	50	44	28	9	9	10	7	7.2	8.7	9.8	3.7	645	2725	19
KILLARNEY PARK	64 Km SW	--	--	84	25	-	-	8	4	---	---	5.8	2.2	334	506	12
NAIRN CENTRE	48 Km WSW	81	64	87	60	7	7	11	17	3.9	4.8	1.2	2.5	392	1415	20
FAIRBANKS L.	37 Km W	--	--	--	45	-	-	--	9	---	---	---	9.7	34	1367	10
RAYSIDE	16 Km NW	22	25	14	14	3	5	7	4	7.0	8.0	7.7	6.6	155	1050	5
MORGAN	24 Km NW	28	29	78	20	8	5	7	6	3.4	2.9	4.2	2.5	643	1665	8

\* DISTANCE AND DIRECTION FROM SUDBURY  
BLIND RIVER AND MATTAWA ARE CONTROL PLOTS

TABLE 12: CONCENTRATIONS OF THE VARIOUS CHEMICAL ELEMENTS IN THE SOIL SAMPLES  
COLLECTED AT THE SUDBURY SURVEILLANCE PLOTS DURING THE 1970, 1971, 1972 AND  
1973 GROWING SEASONS (AVERAGE OF TWO MONTHLY COLLECTIONS)

CHEMICALS

PLOT	LOCATION	To S%				Cu ppm				Ni ppm				Fe %			
		1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973
BLIND RIVER	160 Km W	.02	.03	.04	.02	10	18	5	5	11	2	11	4	.15	.67	.95	.95
MATTAWA	176 Km E	.01	.04	.01	.02	7	7	3	4	7	5	28	4	.39	.65	.69	.46
SUDBURY	Laurentian	.02	.03	.06	.04	265	173	187	268	245	149	235	187	1.58	1.15	1.20	.51
MILNET	37 Km N	.04	.03	.03	.02	33	19	16	9	50	18	20	60	.97	.56	.95	.64
CHINIGUCHI L.	57 Km NNE	---	---	---	.05	--	--	--	14	--	--	--	19	---	---	---	.67
GARSON	5 Km NE	.03	.05	.03	.03	174	105	57	87	215	86	76	97	.102	.69	.65	.43
SKEAD	26 Km NE	.04	.10	.04	.08	125	170	181	179	150	135	116	132	1.12	1.20	1.02	1.01
KUKAGAMI L.	42 Km NE	.05	.06	.05	.02	102	35	119	40	85	42	83	37	1.60	1.28	1.10	1.23
GRASSY L.	64 Km NE	.04	.03	.03	.05	57	28	44	41	68	53	40	34	.60	1.75	1.31	.62
TEMAGAMI	80 Km NE	.04	.02	.03	.02	51	22	39	18	40	32	28	19	.98	.35	1.80	.69
CALLUM	29 Km E	.04	.05	.04	.03	94	37	75	39	60	48	94	55	1.13	1.32	1.30	.49
STURGEON FALLS	77 Km E	.03	.05	.02	.04	23	16	23	20	39	34	65	19	.17	1.05	1.40	.14
ST. CHARLES	48 Km SE	.04	.05	.03	.04	21	24	12	12	31	45	63	25	---	1.52	1.60	.78
BURWASH	27 Km S	.02	.05	.03	.03	27	39	10	28	44	59	27	73	1.15	1.33	.70	.44
TILTON L.	15 Km SW	---	---	---	.05	--	--	--	125	--	--	--	95	---	---	---	.79
PENAGE	37 Km SW	.03	.09	.02	.03	58	82	31	32	79	49	44	29	.14	1.29	1.18	.64
KILLARNEY PARK	64 Km SW	---	---	.05	.03	--	--	43	28	--	--	20	14	---	---	.63	.31
NAIRN CENTRE	48 Km WSW	.03	.09	.02	.03	44	17	40	78	52	40	38	23	.24	.48	1.64	1.42
FAIRBANKS L.	37 Km W	---	---	---	.04	--	--	--	16	--	--	--	19	---	---	---	1.40
RAYSIDE	16 Km NW	.03	.03	.03	.04	67	45	88	68	85	37	82	62	.97	.67	.44	.24
MORGAN	24 Km NW	.01	.03	.02	.02	29	20	18	16	43	23	20	24	1.16	1.17	1.20	.39

\* DISTANCE AND DIRECTION FROM SUDBURY  
BLIND RIVER AND MATTAWA ARE CONTROL PLOTS



Table 13: SUMMARY OF pH VALUES DETERMINED FOR SOIL SAMPLES COLLECTED  
IN THE SUDBURY AREA - 1970 - 1973

Location	June/70	Aug/70	June/71	Aug/71	June/72	July/72	Aug./72	June/73	Aug./73	pH Range	Mean
Skead	4.2	4.2	4.2	4.3	4.2	3.9	4.2	3.9	5.1	3.9-5.1	4.24
Milnet	3.9	4.3	4.2	4.2	4.6	--	5.3	4.9	5.1	3.9-5.3	4.56
Rayside	3.8	4.2	4.6	4.9	4.5	4.0	4.2	4.1	4.3	3.8-4.9	4.29
Grassy Lake	4.6	4.5	5.2	5.2	4.2	--	5.7	4.2	4.4	4.2-5.7	4.75
Kukagami	4.8	4.0	4.6	5.0	4.3	--	4.1	4.5	4.2	4.1-5.0	4.44
Callum	4.9	4.3	4.3	5.0	5.7	--	4.3	4.6	4.5	4.3-5.7	4.70
Garson	4.7	3.9	4.0	4.1	4.3	4.0	4.5	4.1	4.3	3.9-4.7	4.21
Burwash	5.2	5.2	4.6	4.3	5.2	--	5.2	4.6	4.8	4.3-5.2	4.89
Sudbury	4.0	4.0	4.3	4.9	4.7	--	4.0	4.3	4.4	4.0-4.9	4.33
Morgan	5.1	4.9	5.1	5.9	4.7	--	5.6	4.1	5.5	4.1-5.9	5.11
St. Charles	5.3	5.2	4.3	4.4	5.2	--	5.2	5.3	5.0	4.3-5.3	4.99
L. Penage	5.6	4.0	5.2	4.2	4.6	--	4.4	5.0	4.8	4.0-5.6	4.73
Sturgeon Falls	4.2	4.6	4.3	4.9	4.8	--	5.5	5.3	5.3	4.2-5.5	4.86
Nairn	3.9	4.6	4.6	6.3	5.2	--	5.4	4.9	4.5	3.9-6.3	4.93
Temagami	4.5	4.3	4.7	4.2	4.9	--	4.9	4.7	4.3	4.2-4.9	4.56
Killarney	--	--	--	--	4.7	--	3.0	4.6	4.5	3.0-4.7	4.20
Fairbanks	--	--	--	--	--	--	--	4.7	4.3	4.3-4.7	4.50
Tilton	--	--	--	--	--	--	--	4.5	4.5	- 4.5 -	4.50
Chiniguchi	--	--	--	--	--	--	--	4.0	4.5	4.0-4.5	4.25
Blind River	4.3	5.2	4.5	4.5	4.6	--	5.2	5.1	5.1	4.3-5.2	4.81
Mattawa	4.6	5.0	4.7	4.5	5.6	5.2	5.3	5.3	4.8	4.6-5.6	5.00



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